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ABSTRACT

This training manual provides information needed to meet the minimum EPA standards for certification as a commercial applicator of pesticides in the public health pest control category. The text discusses pests such as roaches, bedbugs, bees, mosquitoes, gnats, flies, and rodents with possible control measures provided. (CS)

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COMMERCIAL PESTICIDES APPLICATOR MANUAL:

PUBLIC HEALTH

This manual was adapted for Virgin Islands needs from materials furnished by the Training Branch, Operations Division, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, D.C. It supplements the EPA/USDA publication: "APPLY PESTICIDES CORRECTLY - - A GUIDE FOR COMMERCIAL APPLICATORS." That publication should be read first.

The information herein provides a base to use in preparing for the certification examination in the category of PUBLIC HEALTH PEST CONTROL.

Reference to commercial products or trade names is made with the understanding no discrimination is intended and no endorsement is implied by the College of the Virgin Islands Cooperative Extension Service.

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December, 1975

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
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Agricultural Extension Service, College of the Virgin Islands
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TABLE OF CONTENTS

Public Health Pest Control 1
Public Health Pests 2
Cockroaches 2
Control 3
Sucking lice 3
Control 4
Fleas 5
Control 6
Bedbugs 6
Control 6
Assassin or Kissing Bugs 7
Control 7
Bees, Wasps and Hornets 7
Control 8
Mosquitoes 8
Control 9
Physical control 9
Biological control 10
Personal protection 10
Chemical control 10
Biting Midges 10
Control 10
Eye Gnats 10
Control 11
House Flies 11
Control 12
Spiders 12
Control 12
Pigeons 13
Control 13
Bats 13
Control 14
Rats and Mice 14
Control 16

APPENDIX

Suggested References 18
Household and Stored Food Pests:
Key to common adults 19
Key to common larvae 20
Key to adult beetles 21
Cockroaches: Key to species 22
Cockroaches: Key to egg cases 23
Human Ectoparasites: Key to species 24
Domestic Flies: Key to common species 25
Mosquitoes: Adult female Aedes 26
Mosquitoes: Key to common larvae 27
Mosquitoes: Anophelines and Culicines 28

COMMERCIAL PESTICIDES APPLICATOR MANUAL:

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William D. Fitzwater and Leonard G. Reed, Jr.

The U.S. Environmental Protection Agency has set the following standards for commercial applicators engaged in public health pest control:

"Applicators shall demonstrate practical knowledge of vector-disease transmission as it relates to and influences application programs. A wide variety of pests is involved, and it is essential that they be known and recognized, and appropriate life cycles and habitats be understood as a basis for control strategy. These applicators shall have practical knowledge of a great variety of environments ranging from streams to those conditions found in buildings. They should also have practical knowledge of the importance and employment of such non-chemical control methods as sanitation, waste disposal, and drainage."

Public health pests are animals which:

- - are involved in the transmission cycle of disease agents that affect humans
- - injure humans by biting or stinging
- - cause annoyance or discomfort.

The transmission of pathogenic diseases may involve:

- - disease agents or pathogens, such as viruses, rickettsia, bacteria, fungi, protozoans, etc.
- - reservoirs or the animals where the pathogen can occur in nature
- - vectors or the animals that transmit the pathogen from the reservoir to man
- - hosts or the victims of the pathogen or the animals upon which an ectoparasite, such as a tick, feeds.

PUBLIC HEALTH PEST CONTROL

Effective control of public health pests is usually accomplished by a combination of methods, such as:

- - environmental alteration which may include:
  sanitation or removal of a pest's source of food, shelter or water, as for example, trash and garbage where rats live and feed.
  habitat disruption such as, draining away water from swamps where mosquitoes breed.
  biological control such as, intro-

ducing mosquito-eating fish into bodies of water.
- - exclusion by designing and maintaining buildings and other structures to physically exclude such pests as flies, mosquitoes and rats.
- - use of personal protective measures such as long sleeved shirts, trousers and mosquito repellents.
- - suppression by the use of pesticides or mechanical devices like traps to reduce pest populations.

To be effective in public health pest control you must:
- - recognize and know the life cycles and habits of thepests you are to control
- - know what control methods are available and how and when they should be employed
- - evaluate the public health, economic and environmental benefits and risks of each method or combination of methods.
- - know the local, territory and federal laws governing pesticide use and nuisance abatement
- - be able to choose and use the method or combination of methods which will do the job legally, safely, and effectively.

PUBLIC HEALTH PESTS

Cockroaches

Cockroaches are one of the most commonly encountered insect pest. While there are many kinds the following are the most important human pests in the Virgin Islands:

Name	Description	Habits
American cockroach (Periplaneta americana)	Reddish brown to dark brown. Adults 40-50 mm	Damp basements and sewers. Forage mostly on first floors of buildings. Very common in V. I.
Australian cockroach (Periplaneta australasiae)	Reddish brown to dark brown; yellow markings on thorax; yellow streaks at base of wing covers. Adults 25mm.	Warm, damp places, in or out of doors; forage mostly on first floors of buildings. Not so common in V.I.
Brown-banded cockroach (Supella supellectilium)	Light brown. Mottled, red-brown on wings of female; lighter wings on male. Adults 13mm long.	Live all over a building. Flies readily when disturbed. Very common in V.I.
German cockroach (Blattella germanica	Light brown. Black stripes running lengthwise on back. Adults 16mm long.	Live all over the building, but particularly in kitchens and bathrooms. Very common in V. I.
Oriental cockroach (Blatta orientalis)	Black or dark brown. Vestiges of wings on females; short wings on males. 20-35 mm long. More sluggish than other kinds.	Damp basements and sewers. Forage mostly on first floors of buildings. Not so common in V. I.

Cockroaches affect man by
- - destroying and contaminating food and other materials
- - mechanically transmitting the pathogens that cause intestinal diseases such as diarrhea and dysentary
- - being unpleasant to encounter and leaving filth and odors where numerous.

The stages in the life cycle of a cockroach are:
- - the egg which is enclosed in a distinctive capsule containing several eggs
- - several stages of nymphs which resemble the adults except they have no wings
- - the adult

The entire life cycle take from six months to two years.

Cockroaches

- - are active in the dark
- - usually prefer warm, moist places
- - are scavengers and will eat most any food particles.

CONTROL

Control can be accomplished by:
- - sanitation and good housekeeping to eliminate food and harborage
- - insecticides applied as a residual, bait or space spray. Be careful to observe all limitations on the label when using pesticides in food-handling areas.

Sucking Lice

The sucking lice that affect people are the:
- - head louse
- - body louse
- - crab louse

Louse bites cause severe itching. Scratching the bites can lead to a secondary infection. The body louse transmits louse-borne relapsing fever and epidemic typhus. Outbreaks of these diseases have occurred when large numbers of people have been forced to live together in unsanitary conditions.

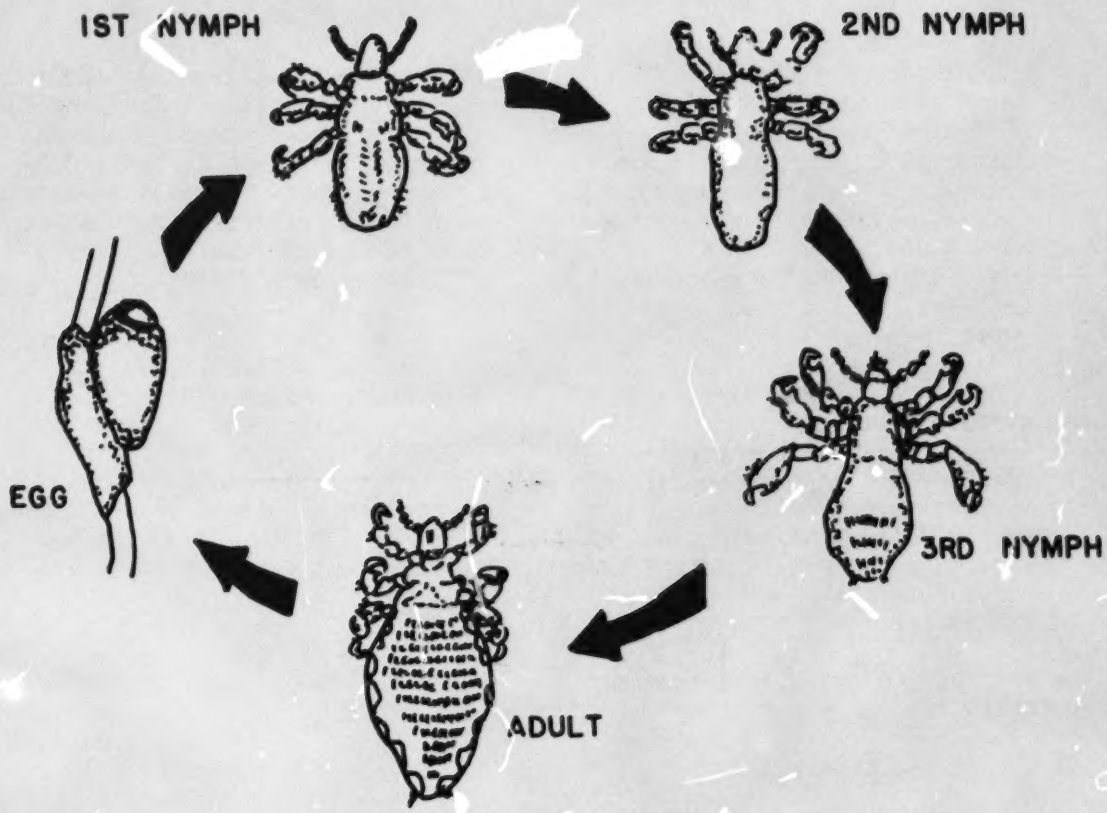
The life cycle stages are:
- - the egg or nit
- - three nymphal stages
- - the adult

The entire life cycle may be completed in one month. Adult head and body lice may live away from the host about 10 days, but the crab louse will die in a day.

The head louse:
- - attaches its nits to the hair close to the scalp. As the hair grows, the nit moves away from the scalp. An active infestation is indicated by nits within 1/2 inch of the scalp.
- - nymphs and adults are found primarily in the hair close to the scalp, most often around the ears and nape of the neck. Sometimes they may be found in hats, combs, brushes or upholstered furniture.
- - is transfered between people who share the same bed, headgear, clothes rack, combs or brushes.

When looking for head lice, examine suspected nits under magnification. Hair sheaths and droplets of hair spray may resemble nits.

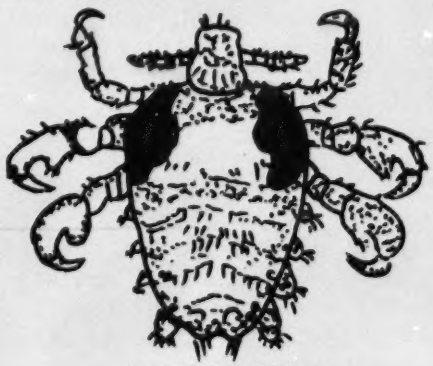
The body louse:
- - attaches its nits to fibers of clothing or to body hairs
- - moves out of the clothing to feed then returns to hide in the seams.
- - is acquired by physical contact or when one shares the same bedding or clothing of an infested person



LOUSE LIFE CYCLE

The crab louse:

- - attaches its nits to the coarse pubic and anal hairs, only infrequently to the body hairs
- - remains on the body, usually in the pubic area
- - is transferred by direct contact, usually sexual, or by means of toliets or beds.



CRAB LOUSE

CONTROL

The control of lice

- - should be carried out in consultation with a physician
- - will be most effective if all persons involved in the infestation (a family, school class, etc.) are examined and, if necessary, all treated
- - can be accomplished by using a pediculicide and drycleaning or laundering headgear, clothing and bedding
- - may be complicated by resistance to pediculicides

Fleas

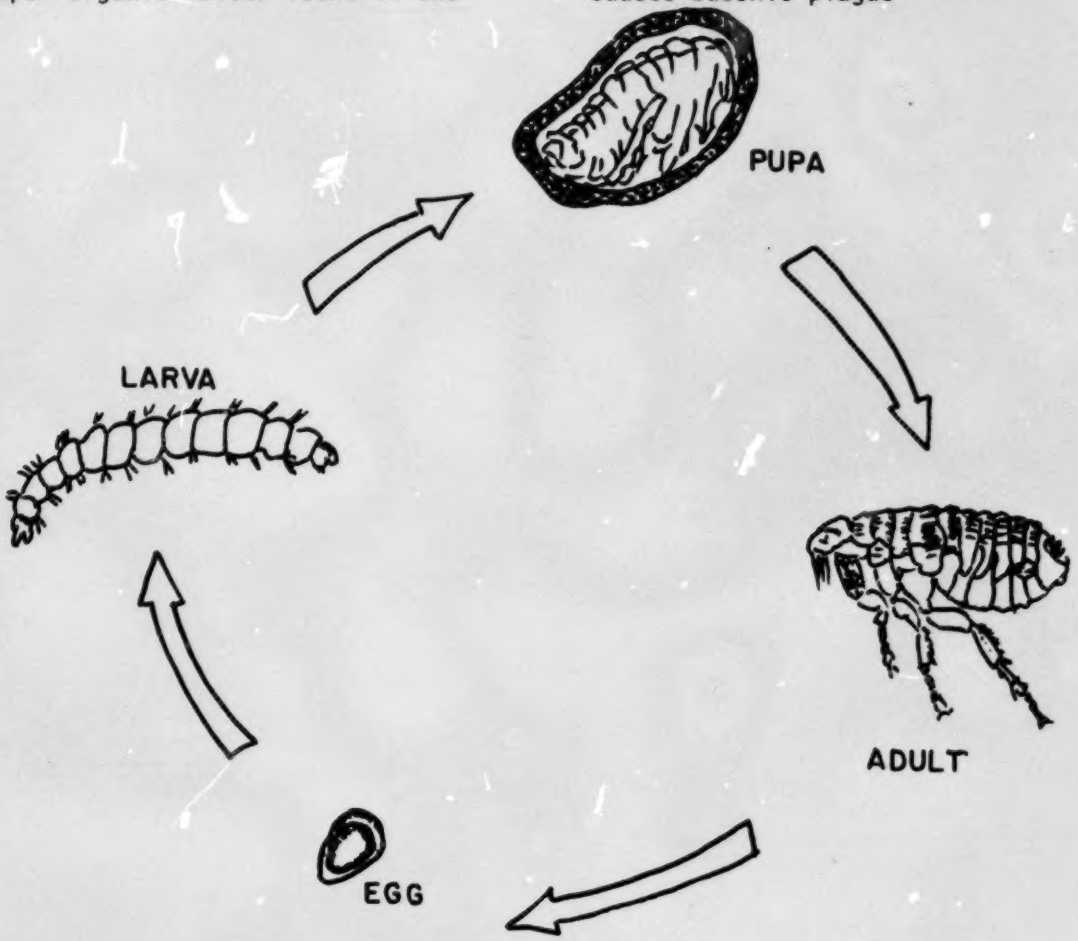
Fleas are wingless, laterally compressed insects from 1 to 8mm long. The legs are adapted for jumping. Spines and bristles on the body are arranged rearward so insects can move easily through the hair or feathers of the host.

The stages in the life cycle of a flea are:

- - the egg, laid loosely on the host or its nest
- - several larval stages which feed upon organic matter found in the nest of the host
- - the pupa, in a silken cocoon made of bits of debris from its surroundings
- - the adult which usually lives in the nest, burrow or bedding of the host returning to it to feed. Adults can live for several weeks without food, but must have blood to produce eggs.

Fleas affect people by:

- - bloodsucking causing irritation
- - transmitting the pathogen that causes bubonic plague



FLEA LIFE CYCLE

5

- - transmitting the pathogen that causes murine typhus
- - serving as an intermediate host for some dog and rodent tapeworms that may infect man

Plague is:
- - a bacterial disease primarily of rodents
- - transmitted to man by the bite of an infected flea or by direct contact with an infected rodent
- - called sylvatic plague when it exists in nature among rodents. This is the disease that has become established in the western United States. It is potentially dangerous for the Islands, though biotics are available to prevent the disasters of ancient plagues.
- - most dangerous to man when it spreads to urban rodent populations where the oriental rat flea is a major vector

Murine (endemic)typhus is:
- - a rickettsial disease of rodents and other animals
- - transmitted to man when infected flea feces are scratched into flea bite wounds or other skin breaks.

The most common species bothering people in houses are the dog and cat fleas. Other than the possible transmission of tapeworms these are more of a nuisance than a public health problem.

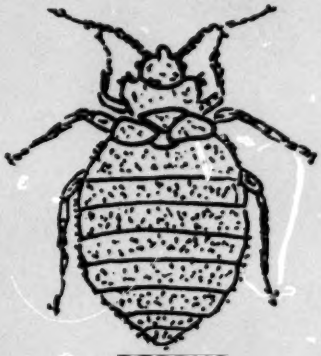
CONTROL

Control of flea infestations is by:
- - cleaning and vacuuming cat and dog quarters followed by application of insecticides
- - excluding wild animal hosts from attics, wall voids, basements, and crawl spaces
- - dusting and gassing burrows of wild rodents in suspect areas

Bed Bugs

The bed bug is primarily a pest of man. It:
- - has not been shown to transmit disease agents
- - sucks blood sometimes causing severe reactions as well as itching and irritation
- - produces a disagreeable odor

The bed bug is a wingless, flat, reddish-brown insect about 8mm long. Similar bugs that normally live on birds or bats may bite people when their normal hosts are absent.



BEDBUG

The stages in the life cycle are:
- - the egg glued inside small hiding places
- - several stages of nymphs that resemble the adult and need a blood meal for each molt
- - the adult

Bed bugs avoid light by hiding in mattress seams and tufts, bedframes, in cracks and crevices, under wallpaper and in similar places. They come out to feed at night. The life cycle may take from one to five months. All stages can survive starvation for several months.

CONTROL

Control measures include:
- - insecticides as the most practical

method of control
- - sprays applied to hiding places Use a pin nozzle for cracks and crevices and a fan or cone nozzle for the mattress. Make sure the mattress is dry before it is needed again.
- - looking for and removing bird nests and bat harborages.

Assassin Or Kissing Bugs

The bloodsucking conenose bugs affect people by:
- - transmitting a trypanosome which causes Chargas disease, important in Central and South Americas
- - injecting saliva when they feed producing a severe allergic reaction in some individuals

Assassin bugs are brown to black, about 18mm long. They have a long, cone-like head and slender beak folded back between the front legs. Similarly shaped bugs which do not suck blood inflict a painful bite.

ASSASSIN BUG

The stages in the life cycle of a conenose bug are:
- - the egg
- - several stages of wingless nymphs, each requiring a blood meal to molt
- - the adult

The entire life cycle may require one to two years. Most medically important assassin bugs inhabit wild animal burrows or nests, but a few live with and feed upon man or domestic animals.

CONTROL

Personal protection includes:
- - keeping bugs out of dwellings by screening doors and windows and sealing cracks and other openings
- - using a bed net

General control:
- - is aided by eliminating wild animal sources of the bugs if possible
- - is accomplished inside dwellings with insecticides.

Bees, Wasps, And Hornets

The hymenopterous insects sting by injecting a venom that:
- - causes pain and swelling
- - may sometimes produce a severe allergic reaction that may result in serious illness of even death

Each of these insects passes through the same life cycle: the egg, several larval stages, pupa and adult.

Their habitats differ:
- - honey bees may build in attics, wall voids, or hollow trees
- - bumblebees nest in the ground
- - hornets build large paper nests above ground
- - yellow jackets build paper nests under eaves, within enclosures, or underground
- wasps (varying with the species) build mud nests, paper nests or dig holes in the ground.

Honey bee colonies may exist for many years. Bumblebees, wasps, hornets and yellowjackets overwinter as young fertilized queens which start new colonies in the spring.

CONTROL

Personal protection includes:
- - avoiding outdoor areas where the insects are abundant
- - not wearing scented toiletries which may attract the insects

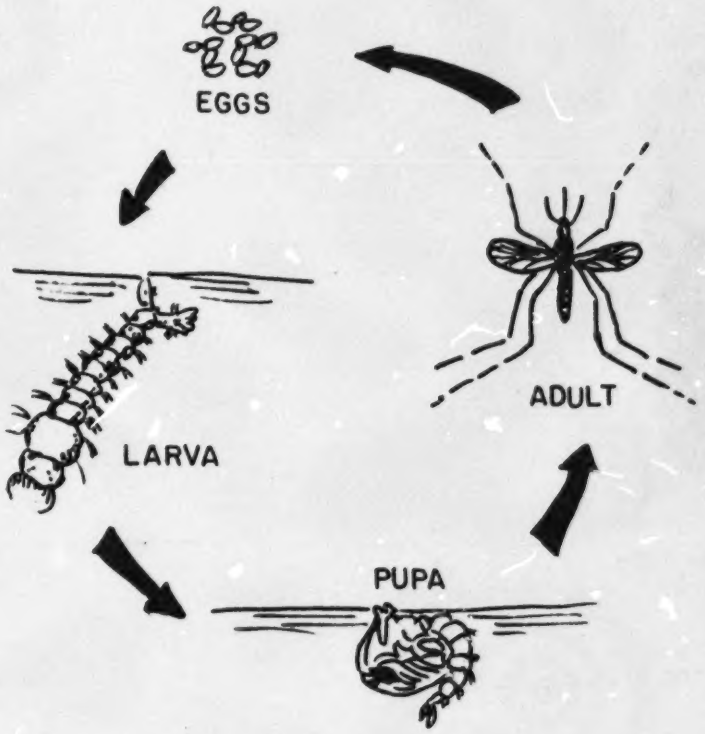
Control of colonies is by:
- - treating nest with a pesticide, either early in the morning or after dark when the insects are inactive. "Freezing" through the use of a carbon dioxide fire extinguisher may immobilize the insects before applying the pesticide
- - using poisoned baits, which yellowjackets carry back to the nest thus killing the larvae

These insects, especially honey bees, are highly beneficial. They should be controlled only if they are a threat to people.

Mosquitoes

Mosquitoes are severe bloodsucking insect pests of people and livestock. They cause severe economic losses as well as suffering and death through the diseases they transmit.

There are many species of mosquitoes but they have the same life cycle - - as shown below:



MOSQUITO LIFE CYCLE

As shown on the preceding page, the life cycle of the mosquito is:

- - the egg which is laid in water or in areas which will later be wet depending upon the species
- - four larval stages which feed on microorganisms and other organic matter
- - pupa which are motile but non-feeding
- - the adult. After males and females mate, the female of most species needs a blood meal in order to produce eggs. The male takes only plant juices.

Mosquito life cycles fall into two general types:

- - permanent-water which stands for long periods. Females lay eggs singly (Anopheles) or in rafts (Culex). Most overwinter as adult females.
- - Flood water where the females deposit eggs in damp soil, debris or plants. The eggs are resistant to drying and survive months or even years until covered with water (Aedes). Most of these mosquitoes overwinter as eggs.

Mosquito surveillance involves:

- - collecting and identifying adults to locate the problem, evaluating its importance, and predicting the larval source
- - collecting and identifying larvae to confirm source of problem, evaluating its importance, and helping choose control methods
- - recording and analyzing data on kinds, numbers, and location of mosquito adults and larvae as well as other conditions that contribute to mosquito production (weather, rainfall, temperature, tide tables, irrigation cycles).

Mosquitoes are of great health importance because of their role in transmitting:

- - encephalitis. These viruses affect the central nervous system causing an inflammation of the brain. Eastern, Western, and St. Louis encephalitis are transmitted to man from bird reservoirs. Californian and Venezuelan encephalitis have mammalian reservoirs
- - malaria. This protozoan disease is transmitted from a sick person to a healthy one
- - yellow fever and dengue. These are other virus diseases which are not as important as before flare up occasionally.
- - filariasis. Diseases caused by roundworms are a serious source of heartworms in dogs in the Virgin Islands.

CONTROL

Mosquito control consists of a combination of control methods in an attempt to maintain mosquito populations at a low level so they do not transmit disease or annoy people seriously.

Physical Control

This means altering the environment to disrupt the mosquito life cycle: It includes:

- - managing land and water by grading and leveling so that water does not stand long enough for larvae to develop.
- - installing dikes and tide gates to keep salt marshes flooded so salt marsh mosquitoes cannot lay eggs.
- - draining, filling or disposing of unnecessary water-holding contain-

ers such as tree holes, unused backyard pools, tin cans, or tires
- - designing and maintaining necessary water-holding structures, cisterns, impoundments, etc. to eliminate or minimize their potential as mosquito sources.

These measures can affect organisms other than mosquitoes. You must determine if these actions would cause unreasonable adverse effect on the environment.

Biological control

This is the use of natural enemies to lower mosquito populations, such as:
- - introducing organisms like mosquito-eating fish into ponds if approved by the Department of Conservation and Natural Resources
- - bats and birds are not effective predators of adult mosquitoes contrary to popular belief.

Personal protection

Protecting yourself from mosquito attacks includes:
- - screening doors and windows
- - avoiding mosquito-infested areas during times they are active
- - using repellents

Chemical control

This can be accomplished in the following ways:
- - larvicides: Oils, pesticides and insect growth regulators are registered for application against the larval stages. This can be an efficient and effective means of control, but in some areas, mosquitoes have become highly resistant to certain chemicals. Many non-target organisms in the aquatic environment may be endangered so obey the label instructions.
- - adulticides: Pesticides for the adult stages can be used as residuals but most are applied as aerosols. These can be hazardous to people and non-target organisms so must be used with caution.
- - herbicides: These pesticides can be used indirectly in mosquito control to kill vegetation that harbors the mosquitoes or in certain cases may furnish oxygen for the larvae. Again restrictions must be observed.

Development of resistance can be delayed by applying pesticides only when and where necessary.

Biting Midges

These small blood-sucking insects (punkies, sand flies, no-seeums) can be serious pests at times. The stages in their life cycle are:
- - the egg laid in salt marshes, freshwater mud holes, highly organic water, etc. depending upon the species.
- - several larval stages which are worm-like and slow in developing
- - the pupa
- - the adult. There is generally only one generation per year.

CONTROL

Control is most difficult. It can sometimes be affected by:
- - applying adulticides with aerial or ground equipment
- - using repellents
- - using very fine wire screening as ordinary screening will not keep them out.

Eye Gnats

Eye gnats affect people by:

- - persistently flying around and alighting upon the face.
- - transmitting pathogens that cause conjunctivitis (pinkeye)

Eye gnats are tiny two-winged insects, 25mm long. Many are dark brown to black, but some are straw-colored.

The stages in the life cycle are:
- - the egg
- - several larval stages which occur in loose soil containing sufficient moisture and organic matter.
- - the adult

CONTROL

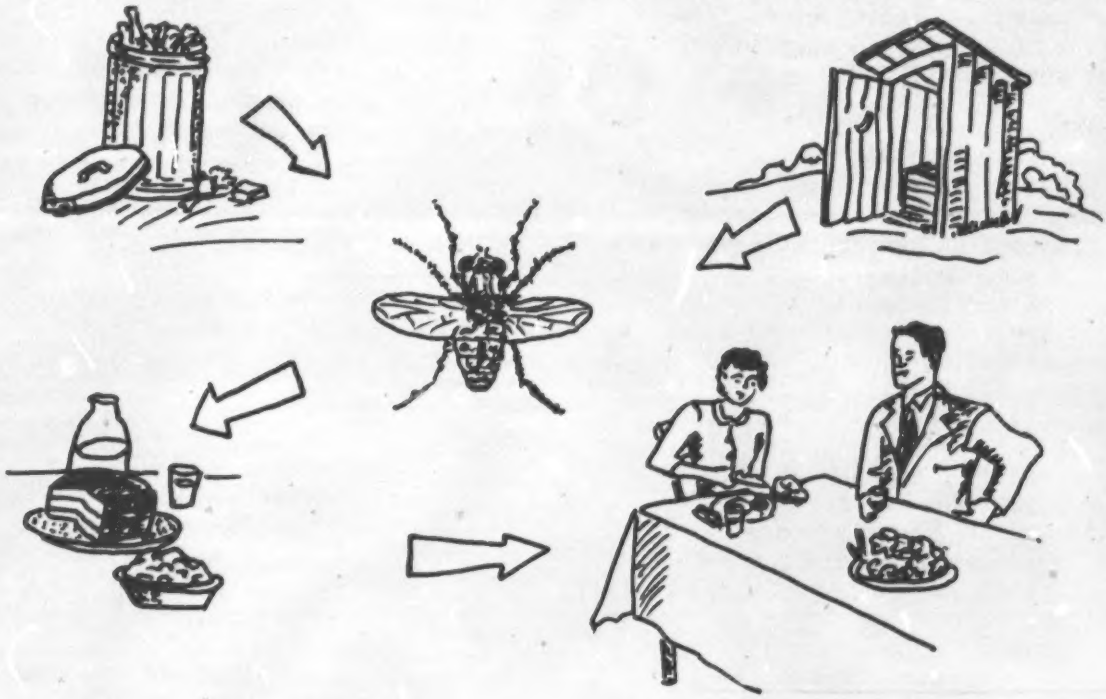
Control is very difficult. It may be achieved by:
- - repellents for personal protection
- - non-tillage of agricultural breeding grounds
- - applying suitable larvicides
- - using traps or poison baits for adult flies.

House-Flies

House flies are small, two-winged insects ranging from 2.5 to 13mm long. They are not only annoying to people but carry pathogens of typhoid, dysentary and other intestinal diseases. In some forms the larval stages live within the body of a host.

The life cycle of a "domestic fly" is:
- - the egg deposited in a moist place
- - several larval stages
- - the pupa which is usually in a drier place than the larvae
- - the adult.

The life cycle typically requires two or three weeks, but can be one to six weeks depending upon the species.



DISEASE TRANSMISSION CYCLE

The house fly develops in many types of moist organic material
- - animal manure
- - garbage
- - decaying plant material
- - fruit and vegetable wastes

This is the most common fly in and around residences.

The little housefly and its relatives develop in:
- - poultry manure
- - decaying plant material
- - garbage
- - animal manure
- - bird, mouse and wasp nests

The face fly lays its eggs only in fresh cattle droppings. Vinegar flies develop in decaying fruits and vegetables. Blow flies develop in dead animals, garbage and manure. Flesh flies develop in manure and dead animals. These deposit live larvae, not eggs, so they infest meat very quickly.

CONTROL

Fly control is based on sanitation. This includes:
- - collecting garbage at least twice a week so they do not emerge in residential areas
- - disposing of garbage so as not to permit the cycle to be completed
- - managing animal wastes by cleaning out, drying or other means to prevent fly emergence
- - properly disposing of cull fruits, vegetables and dead animals
- - frequently turning compost so it decomposes rapidly and maintains a high enough temperature to kill fly larvae
- - sanitary treatment and disposal of liquid wastes and sludge

Exclusion includes:
- - screening doors and windows
- - air barriers (air currents created by strong fans to keep out of areas impractical to screen)

Some biological control is possible with predators and parasites.

Control with pesticides:
- - may result in impressive numbers of dead flies but is only temporary
- - can be useful to supplement sanitation
- - may be hampered by resistance, especially to residual insecticides
- - is difficult to attain with larvicides and these may kill fly predators and parasites too.

Spiders

Many spiders cause minor swelling when they bite people, however, only the black widow can cause a more serious reaction but its bite is rarely fatal. The female is shiny black with a red or yellow "hour-glass" on the belly.

A spider develops from an egg into an immature spider which may molt several times before becoming an adult.

CONTROL

Control is attained by:
- - generally good housekeeping and insect control
- - physically destroying spiders and their webs in local infestations
- - applying pesticides to the places

Pigeons

Most species of birds are economically and esthetically valuable, but pigeons that live in vicinity of humans can be nuisances by:

- - destroying field crops
- - eating and contaminating livestock feed
- - making odiferous and unsightly deposits on buildings
- - contaminating stored food products
- - providing various fungal diseases (histoplasmosis, cryptococcus, etc.) good places to grow in the heavy deposits of droppings
- - serving as reservoirs for a number of diseases, including encephalitis, ornithosis, salmonellosis, Newcastle disease, pseudo-TB, etc.

Pigeons lay one or two eggs which hatch in 18 days. The young leave the nest at four to six weeks. These birds breed all year round. They feed mainly on grains and seeds and require a source of grit and water.

CONTROL

As pigeons unlike most other pests may have vocal supporters who object to killing these animals, the applicator must judge the extent of public opinion regarding the disposal of a particular flock. He should first decide if:

- - environmental sanitation is practical such as discouraging bird feeding, cleanup of grain wastes around food-handling establishments, etc.
- - repellent or exclusion devices can be used such as noise makers, screening, building alterations to eliminate roosting, chemical or mechanical repellents, etc.

If it is decided that reductional methods are practical and warranted, he should evaluate the cost-effectiveness of:

- - trapping
- - shooting individual birds
- - destruction of nests and young
- - chemosterilants
- - avicides

With any control measure, but particularly with the use of avicides, the situation must be thoroughly surveyed. The applicator must:

- - determine in which areas a particular flock roosts, nests, loafs, feeds and waters
- - evaluate which are the most practical sites to attempt control measures (they do not normally feed on loafing sites but prebaiting may encourage them to do so)
- - experiment with various bait bases to find which are most acceptable
- - decide which treatment sites would be less attractive to related but protected species like zenaida doves
- - consider the hazards of uninformed people eating poisoned baits or birds
- - destroy pigeons captured alive humanely as if released they will return to their old haunts
- - wear an approved respirator when exposed to dusty dropping which may contain fungus spores and launder clothing after each exposure
- - pick up dead birds quickly to minimize public reaction.

Bats

Bats affect man by:

- - dropping deposits can be a source of the fungus that causes histoplasmosis
- - transmission of rabies which is common in bats though apparently not present on the Islands
- - making noises, creating odors, and very frightening to some people.

Bats are mammals that feed upon insects. Some species roost singly but most form colonies in caves, trees or buildings. They have a low birth rate, normally one per year, but may live for 20 years. Bats are generally beneficial and should be controlled only when they pose a threat to public health.

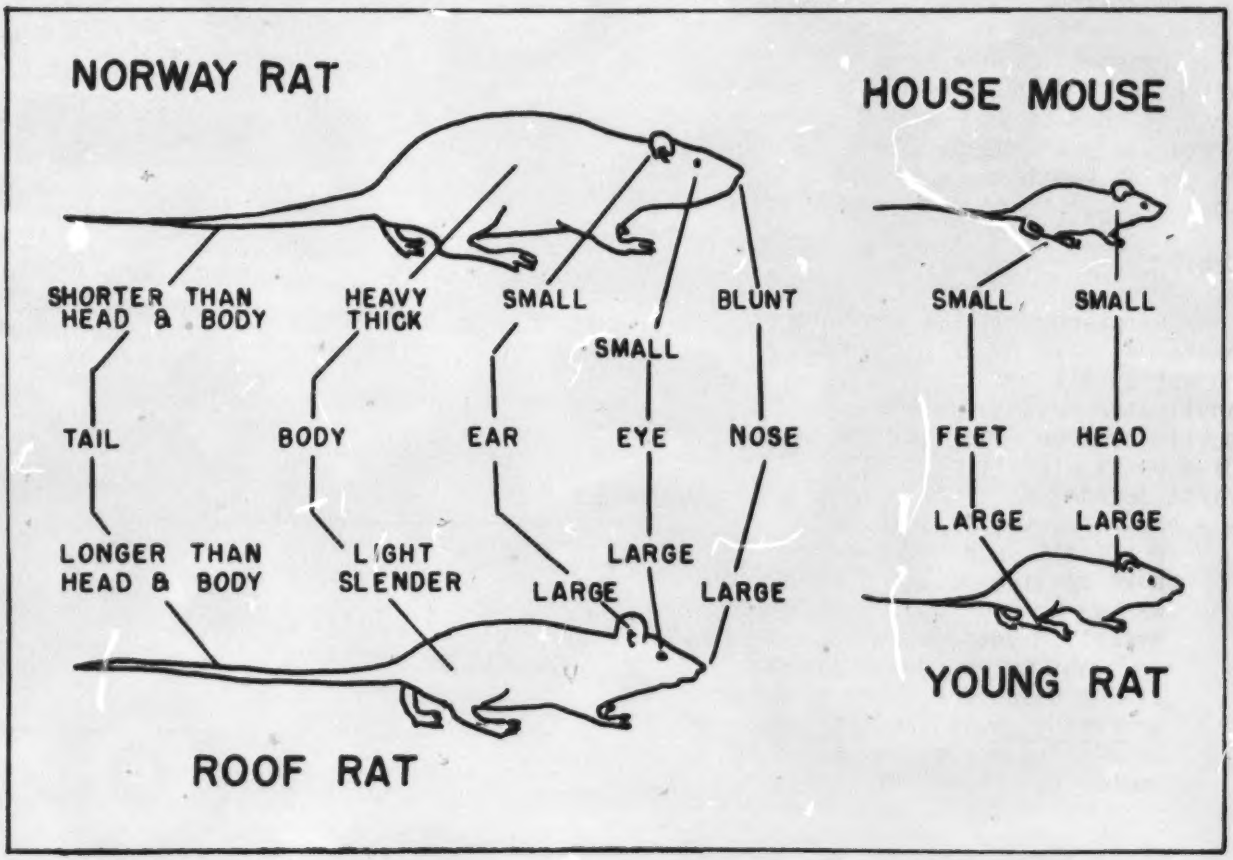
CONTROL

Bat control can be accomplished by:

- - bat-proofing buildings by closing openings 10mm or larger where bats can enter by plugging them with hardware cloth, sheet metal, caulking compound, steel wool, oakum, etcl
- - fumigation by a specialist repellents or pesticides (while several chemicals work there are none currently registered)

Rats And Mice

The most troublesome and expensive



of the vertebrate pests bothering man. They not only cause many millions of dollars of economic damage each year, by contamination and destruction of food and feed, damage to non-edible products and structures, causing fires, biting adults and children, but also by their involvement in the spread of the following:

- - leptospirosis (direct or indirect contact with rodent urine)
- - rat-bite fever (transmitted in saliva by rat bites)
- - salmonellosis (food contaminated by droppings)
- - murine typhus (infected flea feces rubbed into the skin come from rat reservoir)
- - plague (transmitted by bite of infected flea from rat reservoir)
- - rickettsialpox (rickettsial disease associated with mice)

As shown on the preceding page there are three main groups of commensal rodents (those that have adapted living with man):

- - Norway rat
- - roof rat
- - house mouse

Physical and other distinguishing characteristics of these groups are listed below.

Species	Norway rat (Rattus norvegicus)	Roof rat (Rattus rattus	House mouse (Mus musculus)
Weight	280-480 gm	110-340 gm	14-21 gm
Total length	325-46mm	350-450 mm	150-190 mm
Head & body	180-255 mm Blunt muzzle Heavy, thick body	165-205 mm Pointed muzzle Slender body	65-90 mm Pointed muzzle Small
Tail	150-215 mm Shorter than head and body Lighter on underside	190-255 mm Longer than head and body Uniform coloring	75-100 mm Equal or somewhat longer than head and body
Ears	Small, closeset	Large prominent	Prominent for body size
Sexually mature	2-3 months	2-3 months	1.5 months
Litters/year	4-7	4-6	Up to 8
No./litter	8-12	6-8	5
Pregnancy	22 days	22 days	19 days
Droppings	Blunt ends 13-18 mm	Spindle shape 8-13 mm	Rod shaped 4-6 mm

The Norway rat is primarily a burrowing rodent while the roof rat adapts well to an aboreal habitat. Rats have an average feeding range of 100-200 feet or more whereas mice may be restricted to 10-30 feet. While rats are shy of new objects in their environment, mice are more apt to investigate any changes. All of them have:

- well-developed sense of touch in certain body hairs which is why they like to run next to walls and other solid objects
- good eyesight in darkness but cannot distinguish objects at a distance and are color blind
- keen sense of smell but not repelled by human odors
- very discriminating sense of taste
- keen hearing that is sensitive to higher sounds than human ears
- excellent balance in jumping and climbing

Commensal rodents are mostly nocturnal though under certain conditions can be seen during the day. However, their presence can be readily detected by:

- droppings
- runways in vegetation, greasy smears indoors
- burrows (normally made by Norway rats but the others will also use burrows)
- gnawing (small chisel-like marks as they keep their incisor teeth worn down)
- tracks
- odors and urine stains

CONTROL

The size of a rodent population present in a given area is dependent upon environmental factors. Thus long-lasting control is dependent on a balanced program that seeks to eliminate these life essentials by:

- sanitation - removal of all possible sources of food, water, and shelter
- rodent-proofing - exclusion of rodents from areas where these life essentials are available
- reductional measures - use of rodenticides, tracking poisons, and traps for immediate reduction in numbers
- continual maintenance of the above programs to insure that sanitation is being practiced, rodent-proofing structures remain tight, and reductional controls are repeated as necessary.

The specifics of these programs include:

Environmental Sanitation

- Manage refuse by storing it in rodent-proof containers of sufficient size and removing these at frequent enough intervals for proper disposal so as not to furnish food and shelter for rodents.
- Store rodent-usable materials and supplies 12-18 inches off the ground and away from walls or in rodent-proof containers or areas.
- Sweep floors regularly and promptly stop all leaks to cut down on these sources of food and water.

Rodent-proofing

- Take rodent-proofing designs into consideration when planning new structures or modifying old ones.
- Doors, windows, and other openings through which rodents might enter should have less than 1/4 inch (1/2 inch in case of rats only) clearance.

- - Use rat-resistant materials (26 gauge or heavier sheet metal, hardware cloth or masonry products) near grade level.
- - Dead spaces such as double-walls or floors should be removed or blocked insofar as possible.
- - The area 3 feet above and below ground should be secured (all possible openings closed with rat-resistant materials) from rodent access. In addition it is necessary to use rat guards on pipes and utility lines that go above this area to prevent climbing.

Reductional Measures

- - Before any of the above are attempted, reductional controls should be applied to reduce numbers. This serves to kill a greater number before they become suspicious at changes in their environment and also reduces the number that would move to other areas when the environment is disturbed.
- - Poisoning is the most productive measure on a cost per animal kill basis but you must use attractive, correctly proportioned and mixed baits placed in areas attractive to rodents.
- - Chemical rodenticides consist of single or multiple dose baits and tracking dusts.
- - Single dose poisons usually kill with one feeding on the bait. As rodents are often able to detect the chemical, it is necessary that these be carefully prepared. It is also advisable to expose untreated foods of the same base as the prepared bait for at least 3 days before poisoned material is provided.
- - Multiple dose baits (anticoagulant poisons) need not be prebaited but they must be kept fresh and palatable.
- - Tracking dusts are picked up on an animal's feet and fur and taken into the body when the animal cleans itself. These must be placed in areas where they cannot contaminate food and feed supplies.
- - All competitive sources of food and water should be removed insofar as possible at the start of baiting. Water baits should be used to supplement dry baits.
- - Where it is dangerous or impractical to use poisons, trapping can be used. Common snap traps modified with an expanded bait pan placed perpendicular to rodent travel paths are most effective. Use large numbers. For mice place these within 10 feet of each other and within 20 feet for rats.
- - For underground infestations or inside gas-tight structures, fumigation is an effective reductional control measure when applied by a fumigation expert.

Continual Maintenance

- - It is important that regular routine inspections be made of a premise to assure sanitation practices are being followed, rodent-proofing structures are intact, and reinvasion detected.
- - Look for the signs of rodents mentioned above. Detection can be aided by painting a 6-inch, white strip around walls, sweeping up all old evidences of rodents, and placing tracking patches (light covering of dust, talc, flour, etc.) in likely habitat.

APPENDIX: SUGGESTED REFERENCES

Mallis, Arnold
1973. Handbook of Pest Control. 1158p McNair-Dorland Co.

Truman, L.C. and W.L. Butts
1967. Scientific Guide to Pest Control Operations. 187p Harvest Publishing Co., Cleveland, Ohio

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1967 Pictorial Keys to Arthropods, Reptiles, Birds and Mammals of Public Health Significance. 192p Public Health Service, CDC Atlanta, GA

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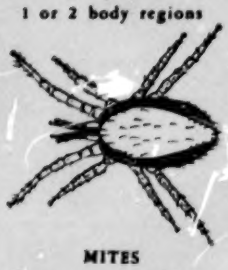
1971. Military Entomology Operational Handbook (NAVFAC MO-310; Army TM 5-632; Air Force AFM 91-16). U.S. Supt. of Documents, Washington, D.C. 20402

HOUSEHOLD AND STORED-FOOD PESTS: KEY TO COMMON ADULTS

Harold George Scott & Chester J. Stojanovich

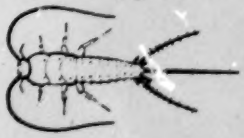
1 or 2 body regions — 3 body regions



MITES

wings well developed — wings reduced or absent

with 3 long tails — without 3 long tails



SILVERFISH

antenna 4-7 segmented — antenna more than 7 segmented

SPRINGTAILS

tarsus 4-5 segmented — tarsus 1-3 segmented

PSOCIDS

with narrow waist — without waist

ANTS — **COCKROACHES**

front wings shell-like — front wings not shell-like

BEETLES—WEEVILS—BORERS—MEALWORMS

1 pair wings — 2 pair wings

FLIES

wings with scales — wings without scales

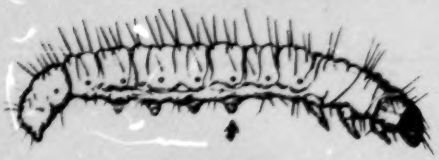
MOTHS — **COCKROACHES**

22

HOUSEHOLD AND STORED-FOOD PESTS: PICTORIAL KEY TO COMMON LARVAE

Chester J. Stojanovich & Harold George Scott

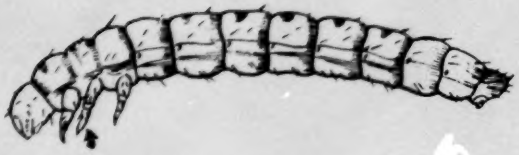
abdominal legs present



abdominal legs absent

MOTH LARVAE

thoracic legs present

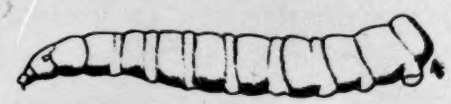


thoracic legs absent

BEETLE, BORER & MEALWORM LARVAE

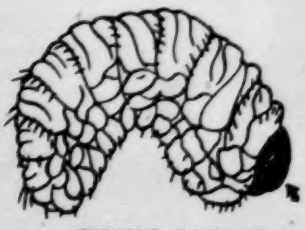
with fleshy lobes at ends of body

without fleshy lobes at ends of body



FLEA LARVAE

head capsule present



WEEVIL LARVAE

head capsule absent

MUSCOID FLY LARVAE

BEETLES: PICTORIAL KEY TO SOME SPECIES COMMONLY ASSOCIATED WITH STORED FOODS

Harry D. Pratt

PRONOTUM WITH 6 TEETH ON EACH SIDE
BEAK ABSENT; SPECIES ABOUT 1/8 INCH LONG

SAW-TOOTHED GRAIN BEETLE
Oryzaephilus surinamensis

PRONOTUM WITHOUT TEETH ON EACH SIDE
BEAK ABSENT

PRONOTUM WITHOUT TEETH ON EACH SIDE
BEAK PRESENT; SPECIES ABOUT 1/8 INCH LONG

SMALL BROWNISH SPECIES
LESS THAN 1/4 INCH LONG

LARGER BLACKISH SPECIES
1/4 TO 3/4 INCH LONG

EACH FORE WING WITH 2 PALE SPOTS
PRONOTUM WITH ROUND PUNCTURES

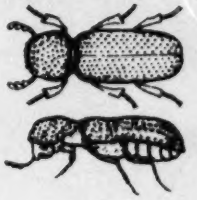
RICE WEEVIL
Sitophilus oryzae

EACH FORE WING DARK
PRONOTUM WITH ELONGATE PUNCTURES

GRANARY WEEVIL
Sitophilus granarius

HEAD VISIBLE FROM ABOVE
1/8 INCH LONG OR MORE

HEAD HIDDEN UNDER PRONOTUM
LESS THAN 1/8 INCH LONG



CONFUSED AND RED FLOUR BEETLES
Tribolium confusum AND *castaneum*

FLATTENED BEETLES
1/4 TO 1/2 INCH LONG
PRONOTUM SEPARATED BY STRONG
CONSTRICTION FROM BASES OF WINGS

CADELLE
Tenebroides mauritanicus

CONVEX BEETLES
1/2 INCH LONG OR MORE
PRONOTUM NOT SO STRONGLY
SEPARATED FROM BASES OF WINGS

YELLOW MEAL WORM
Tenebrio molitor

FORE WING WITH ROUGHENED SURFACE

LESSER GRAIN BORER
Rhyzopertha dominica

FORE WING WITH LINES

DRUG STORE BEETLE
Stegobium paniceum

FORE WING SMOOTH

CIGARETTE BEETLE
Lasioderma serricorne

COCKROACHES: PICTORIAL KEY TO SOME COMMON SPECIES

Harry D. Pratt

SMALL, ABOUT 5/8" OR SHORTER

PRONOTUM WITH 2 LONGITUDINAL BLACK BARS

GERMAN COCKROACH
(Blattella germanica)

PRONOTUM WITHOUT LONGITUDINAL BLACK BARS

WINGS COVERING ABOUT HALF OF ABDOMEN PRONOTUM ABOUT 1/4 INCH WIDE

WOOD ROACH
(Parcoblatta spp.)

WINGS COVERING NEARLY ALL OF ABDOMEN OR EXTENDING BEYOND. PRONOTUM NARROWER

BROWN-BANDED COCKROACH
(Supella supellectilium)

MEDIUM TO LARGE, LONGER THAN 5/8 INCH

WINGS ABSENT, OR SHORTER THAN ABDOMEN

WINGS ABSENT

WINGS SHORTER THAN ABDOMEN

ORIENTAL COCKROACH
(Blatta orientalis)

WINGS COVERING ABDOMEN, OFTEN EXTENDING BEYOND

PRONOTUM MORE THAN 1/4 INCH WIDE

PRONOTUM ABOUT 1/4 INCH WIDE WITH PALE BORDER

WOOD ROACH
(Parcoblatta spp.)

FRONT WING WITHOUT PALE STREAK. PRONOTUM SOLID COLOR, OR WITH PALE DESIGN ONLY MODERATELY CONSPICUOUS

PRONOTUM SOLID DARK COLOR. GENERAL COLOR VERY DARK BROWN TO BLACK.

SMOKY BROWN COCKROACH
(Periplaneta fuliginosa)

PRONOTUM USUALLY WITH SOME PALE AREA. GENERAL COLOR SELDOM DARKER THAN REDDISH CHESTNUT

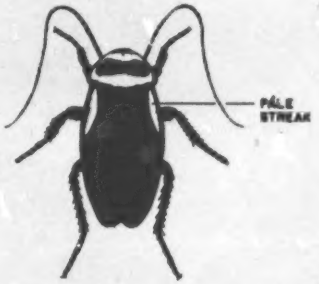
LAST SEGMENT OF CERCUS NOT TWICE AS LONG AS WIDE

BROWN COCKROACH
(Periplaneta brunnea)

LAST SEGMENT OF CERCUS TWICE AS LONG AS WIDE

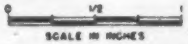
AMERICAN COCKROACH
(Periplaneta americana)

FRONT WING WITH OUTER PALE STREAK AT BASE. PRONOTUM STRIKINGLY MARKED



AUSTRALIAN COCKROACH
(Periplaneta australasiae)

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center
Training Branch
Atlanta, Georgia – 1953

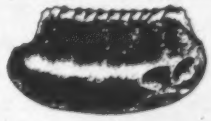


COCKROACHES: KEY TO EGG CASES OF COMMON DOMESTIC SPECIES

Harold George Scott, Ph D. and Margery R. Borom

less than ¼" long subsegments apparent

more than ¼" long subsegments inapparent



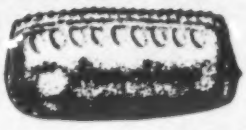
with about 16 subsegments length more than twice width

Blatella germanica
GERMAN COCKROACH

with about 8 subsegments length less than twice width

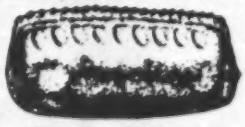
Supella supellectilium
BROWN-BANDED COCKROACH

with lateral indentations



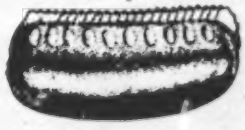
without lateral indentations

terminal point strong



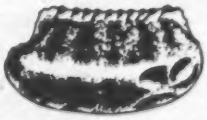
Periplaneta brunnea
BROWN COCKROACH

terminal point weak



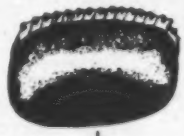
Periplaneta fuliginosa
SMOKY-BROWN COCKROACH

not symmetrical

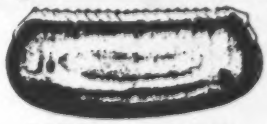


Blatta orientalis
ORIENTAL COCKROACH

symmetrical



length more than twice width



Periplaneta australasiae
AUSTRALIAN COCKROACH

length less than twice width

Periplaneta americana
AMERICAN COCKROACH

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center, Training Branch
Atlanta, Georgia – 1965

HUMAN ECTOPARASITES: KEY TO COMMON GROUPS

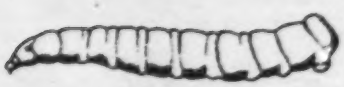
Chester J. Stojanovich and Harold George Scott

legs absent

legs present

head definite
3 pairs of legs

head indefinite
4 pairs of legs



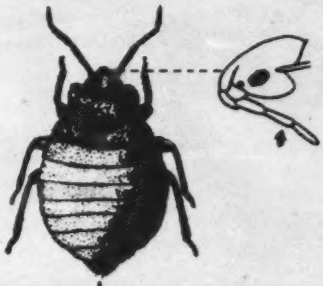
FLY LARVA
Order Diptera

flattened laterally

flattened dorsoventrally

beak jointed

beak not jointed



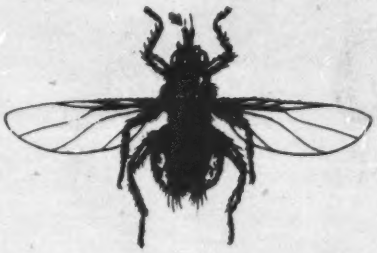
FLEA
Order Siphonaptera

wings present

wings absent

mouthparts projected

mouthparts retracted



KISSING BUG
Order Hemiptera

BED BUG
Order Hemiptera

LOUSE-FLY
Order Diptera

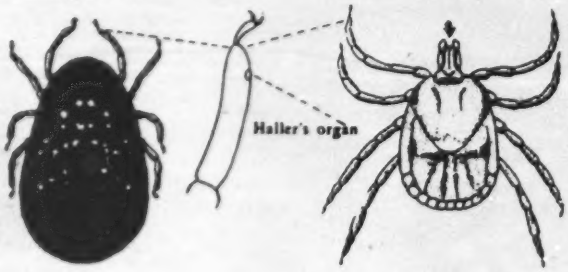
LOUSE
Order Anoplura

over 4 mm. long; Haller's organ present

under 4mm. long; Haller's organ absent

mouthparts ventral

mouthparts anterior



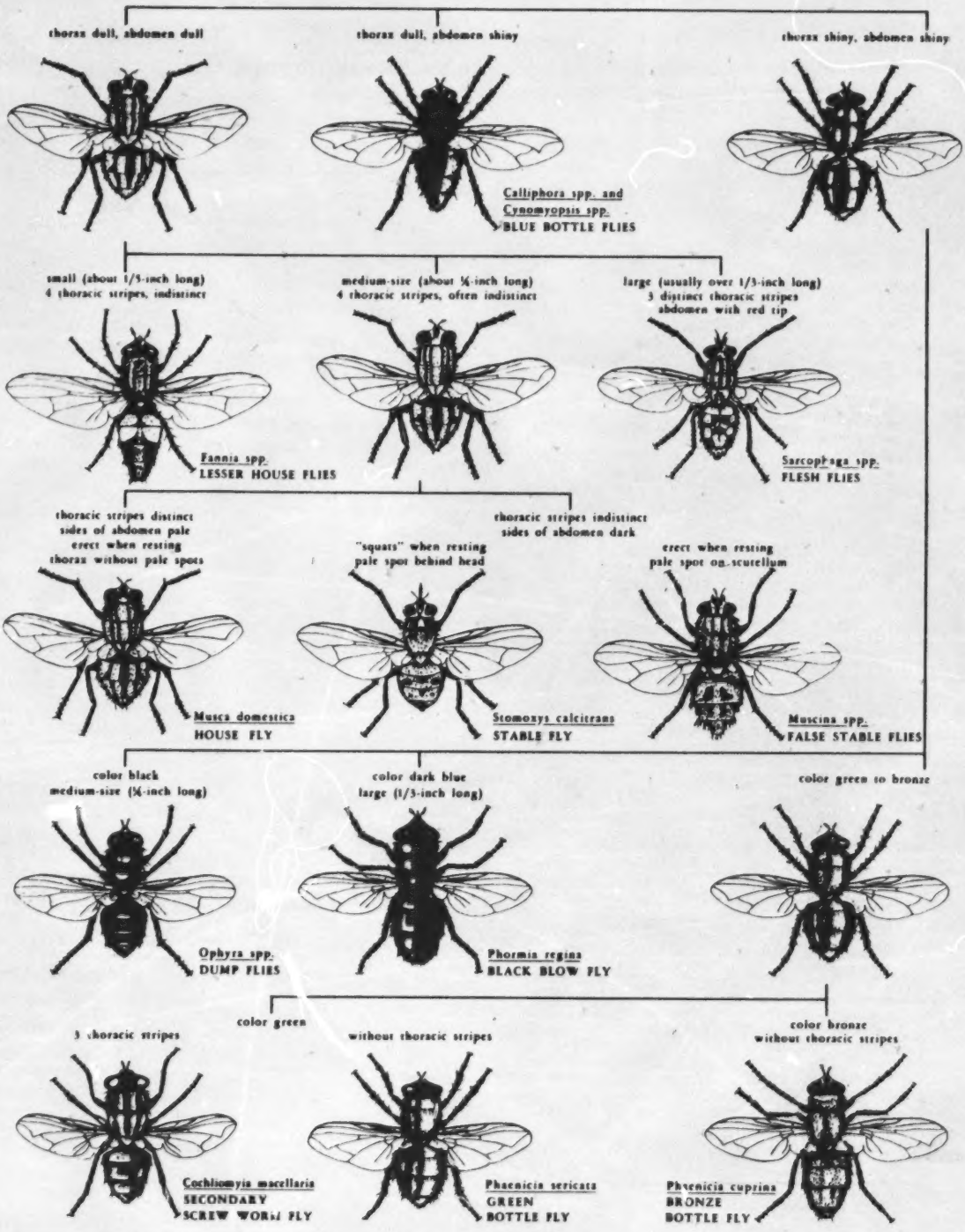
SOFT TICK
Order Acarina

HARD TICK
Order Acarina

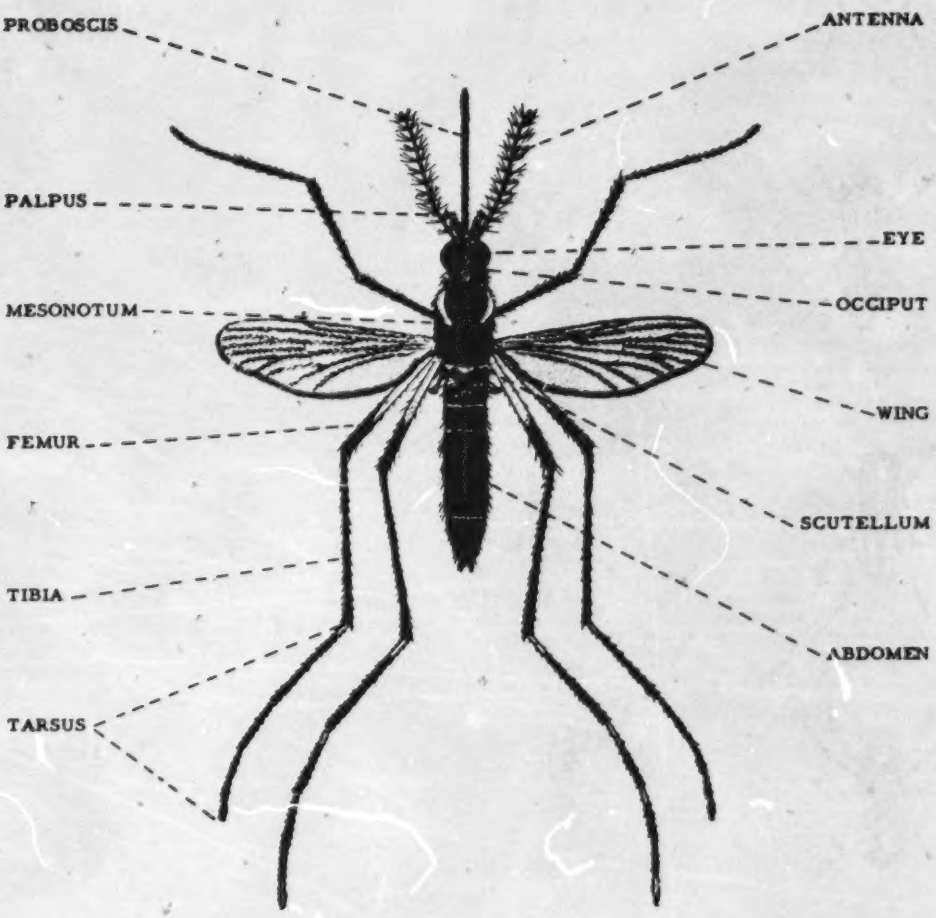
MITE
Order Acarina

DOMESTIC FLIES: PICTORIAL KEY TO COMMON SPECIES

Harold George Scott and Margery R. Borom



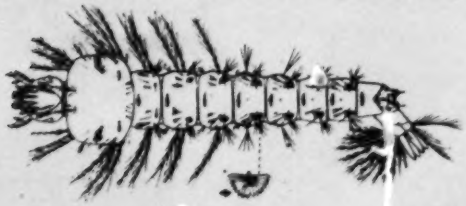
MOSQUITO DIAGRAM – ADULT FEMALE AEDES
Chester J. Stojanovich and Harold George Scott



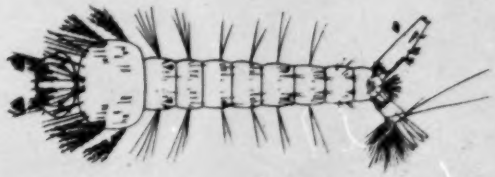
MOSQUITOES: PICTORIAL KEY TO SOME COMMON LARVAE OF PUERTO RICO FOUND IN CONTAINERS

Harry D. Pratt and Chester J. Stojanovich

air tube absent, abdomen with palmate hairs



air tube present, abdomen without palmate hairs



outer clypeal hair not densely branched inner clypeal hairs separated by at least width of basal tubercle

Anopheles albimanus

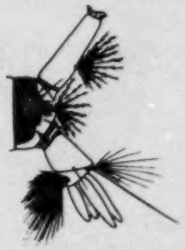
outer clypeal hair densely branched inner clypeal hairs separated by less than width of basal tubercle

Anopheles grabhamii

air tube without pecten

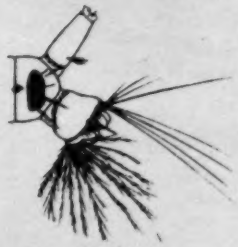
air tube with pecten

comb scales present on 8th abdominal segment



Orthopodomyia signifera

comb scales absent on 8th abdominal segment



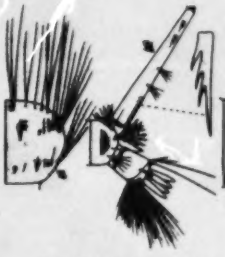
Toxorhynchites portoricensis

air tube with several tufts on each side

air tube 3-5 times as long as wide thorax without spicules

Culex quinquefasciatus

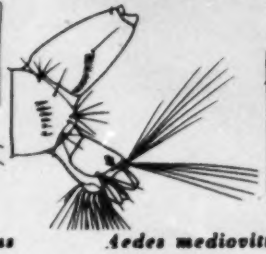
air tube at least 6 times as long as wide thorax with spicules



Culex nigripalpus

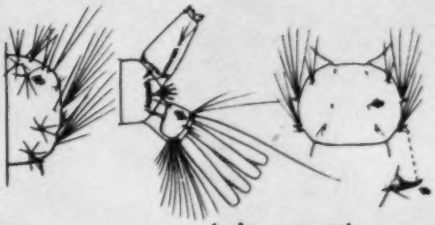
air tube with one tuft on each side

thorax with stellate hairs thorax without prominent lateral spines saddle with posterior spines



Aedes mediovittatus

thorax without stellate hairs thorax with prominent lateral spines saddle without posterior spines



Aedes aegypti

MOSQUITOES: CHARACTERISTICS OF ANOPHELINES AND CULICINES

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